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Types of Microbialites and its Reservoir Rock Characteristics of the Mesoproterozoic Wumishan Formation in Jixian County, Tianjin, China

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The North China area is characterized by rifting and rift trenches developed during the Proterozoic, including the Yanliao rift trench, which started forming at 1.8Ga, and the Wumishan Formation, which was deposited during the middle Mesoproterozoic (Cui et al., 2000; Wang et al., 1995). The rift trough was formed last. Jixian County in Tianjin is located in the center of a strong depression of geological background with a total sedimentary thickness of 10,000m. The Wumishan Formation has a sedimentary thickness varying from 1,030m to 5,400m in the North

China area. Jixian County lies in the center of strong depression of the Yanliao rift trench, strong depression of geological background, with sedimentary thickness reaching 3,300m, and belong to carbonates tidal flat deposit.

Through macroscopic description of microbialites of the Wumishan Formation from the lower, middle, and upper typical profiles include ① M2, ② M6, ③ M8, and ④ M11 as the second, sixth, eighth, and eleventh members of the formation, respectively, in Jixian County, Tianjin, China,

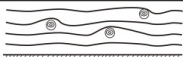
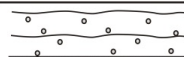
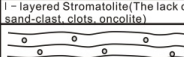
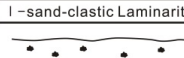
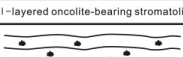
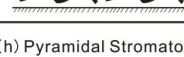
Type	Sketch of microbialite subtype			Legend
Stromatolitic Microbialite	(a) Layered Stromatolite (I - VI)			 Clot  sand-clasts  Oncolite  Microbial laminae The laminae are formed by directionally arrayed clots  Dissolution pores and vugs  Coats of Microbial laminae
			(b) Laminarite (I, II)	
	I-layered Stromatolite (The lack of sand-clast, clots, oncolite)	II-layered oncolite-bearing stromatolite		
		III-sand-clastic Layered Stromatolite		
	IV-Clotted Layered Stromatolite		I-sand-clastic Laminarite	
	V-Layered Clotted Stromatolite	VI-random clotted stromatolite	II-Clotted Laminarite	
		(c) Mounded Stromatolite		
	(d) Wavy Stromatolite		(e) Columnar Stromatolite	
	(f) Palmate/phaceloid stromatolite		(g) Small-columnar Stromatolite	
		(h) Pyramidal Stromatolite		
Non-stromatolitic Microbialite	(i) Oncolite	(j) Thrombolite	(k) Clotted/psammite-coated Microbe	

Fig. 1. Classification of microbialite types of the Wumishan Formation in Jixian county, Tianjin, China.

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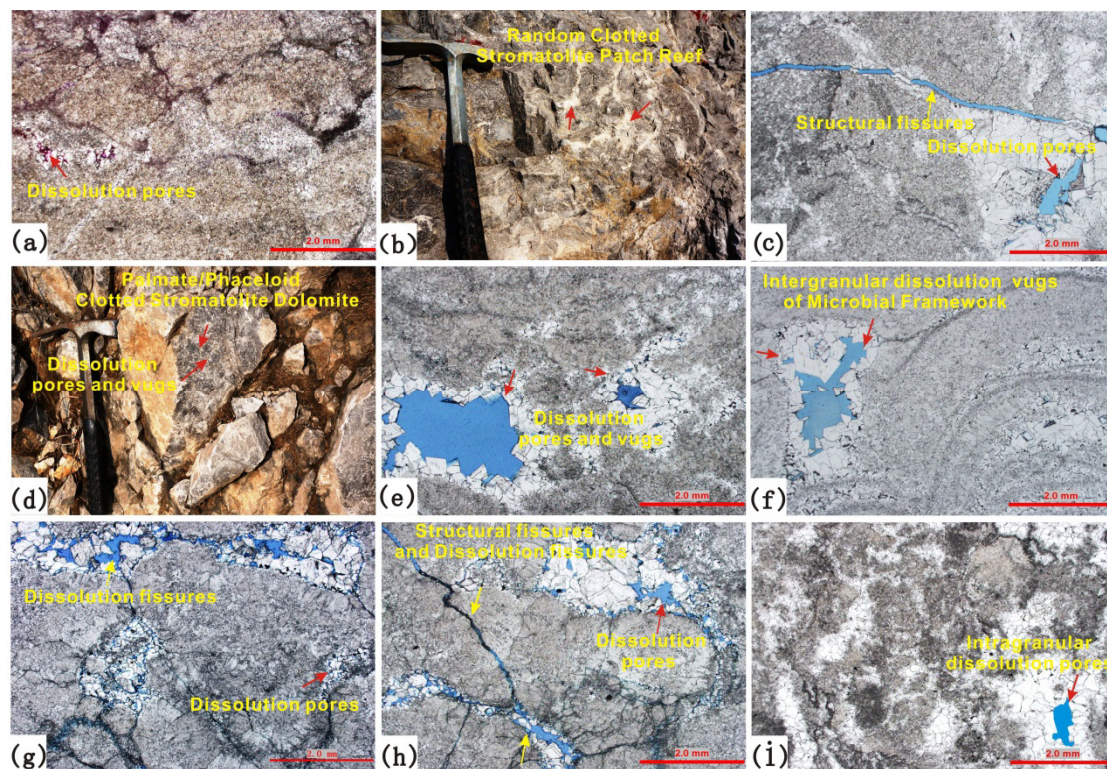


Fig. 2. Reservoir space types of microbial dolomites of the Wumishan Formation in Jixian County, Tianjin, China.

(a)- 42nd Bed of the Eleventh member, Xiaolingzi Formation, NO42-2-2W, including layered clotted lamellar dolomites, in which Visible dissolution pores development (marked by red arrow). (b)- 40nd Bed of the Eleventh member, Xiaolingzi Formation including dark gray, massive, layered clotted crystalline powder dolomite. Laminae are random and include microbial mounds. Dissolution pores and vugs are developed between clots; most are filled with silty-coarse crystalline dolomite (marked by red arrow). (c)- 40nd Bed of the Eleventh member, Xiaolingzi Formation, No. 40-1, under plane polarized light, including random sand-size clotted laminated crystalline dolomite with a surface pore and fissure percentage of 4% composed of 2.5% structural fissures (marked by yellow arrow) and 1.5% dissolution pores (marked by red arrow). (d)- 42nd Bed of the Eleventh member, Xiaolingzi Formation, under plane polarized light, including dark gray massive palmate/phaceloid clotted stromatolite dolomite, with dissolution pores and vugs relatively developed (marked by red arrows). (e) 42nd Bed of the Eleventh member, Xiaolingzi Formation, No. 42-2-6, including palmate/phaceloid clotted, laminated silty dolomite with a surface pore percentage of 2% and pore size of 0.03-2.8mm (marked by red arrows). (f)- 45nd Bed of the Eleventh member, Xiaolingzi Formation, No. 45-4-2, including small-columnar clotted laminated silty dolomite with a surface pore percentage of 3%. Intergranular dissolution pores are developed between microbial framework (marked by red arrow). (g) 45nd Bed of the Eleventh member, Xiaolingzi Formation, No. 45-4-5, including small-columnar clotted/psammitic laminated dolomite with a surface pore percentage of 6% composed of 2% dissolution pores (marked by red arrow) and dissolution fissure (marked by yellow arrow). (h) 5-2nd Bed of the Eighth member, Huliyu Formation, No.HL5-6W, including pyramidal clotted laminated dolomite with a surface pore and fissure percentage of 5%, including 2% structural and dissolution fissures (marked by yellow arrows) and 3% dissolution pores (marked by red arrows). (i) Microbial-coated silty crystalline dolomite, in which clots and sand-sized clasts as the center of coats, with surface pore percentage of 1.5%, and intragranular dissolution pores are developed in microbial coats; eleventh member of Xiaolingzi Formation, NO. 45-4-7. Photographs in (b) and (d) were taken in the field; (a), (c) and (e)-(i) are plain light images.

the authors identified the Wumishan Formation as being lithologically dominated by microbial dolomite (Note: the protolith was microbial limestone in the study area (Song et al., 1991)). The classification of microbialite types from Riding (2000) and Mei et al. (2007), this study classifies microbialites in detail on the basis of their macroscopic textures and structures as stromatolithic microbial dolomite and non-stromatolithic microbial dolomite types and includes 11 subtypes (For details see Fig. 1).

In combination with a study on pores and vugs developed characteristics of microbial dolomite, the authors determined the reservoir rock types of microbial dolomite, including: 1) microbial dolomite associated with

clots and stromatolites, which are layered clotted stromatolite dolomite, layered / random clotted stromatolite dolomite, pyramidal clotted stromatolite dolomite, small columnar clotted stromatolite dolomite, palmate/ phaceloid clotted stromatolite dolomite (Figs. 2a, 2b, 2c, 2d, 2e, 2f, 2g, 2h); 2) microbes capture, binding clots forming the dolomites of coats type that is clots/ sand-clastic microbial coated dolomite (Fig. 2i).

In terms of reservoir spaces development, the main reservoir spaces are dissolution pores of along the laminae boundary of microbialites associated with microbial laminae and clots (Figs. 2a, 2d, 2e, 2g, 2h, 2i). Secondly, they are intergranular dissolution pores and vugs of

microbial framework and the structural and dissolution fissures that developed not regularity, relatively speaking (Figs. 2b, 2c, 2f, 2h).

In a word, through the above researchs, preliminary believed development of the reservoir spaces of microbial rocks mainly by its own structure, microbial framework, the paleokarst and filling degree of comprehensive controltion. The authors identified microbial dolomite as important deep oil and gas exploration targets of the Mesoproterozoic Wumishan Formation in Jixian County, Tianjin, China.

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